Competition of Field Emission from CNT Films Produced by Five Different Techniques

A.V. Karabutov[1], S.M. Pimenov[1], V.I. Konov[1], E.D. Obraztsova[1], V.G. Pereverzev[1], A.S. Pozharov[1], S.V. Terekhov[1], P.Ya. Detkov[2], E.V. Shorokhov[2], E.N. Loubnin[3]

[1)] General Physics Institute, 38 Vavilova street, 119991 Moscow, Russia

[2)] RFNC-RITF, 13 Vasilieva street, 456770 Snezhinsk, Chelyabinsk region, P.O. 245, Russia

[3)] Institute of Physical Chemistry, 31 Leninsky prospect, 117915 Moscow, Russia

Carbon Nanotube (CNT) based field electron emitters are attractive for numerous applications, but there are a lot of methods to produce such emitting coatings, and a question is still open, which one is better. Here we study the field electron emission properties of CNT films produced by different techniques on Si, metal and glass substrates: (i) electrophoretic deposition of single-wall and multiwall CNT onto conducting substrates from alcohol suspensions, (ii) catalytic pyrolysis of multiwall CNT, (iii) formation of CNT films on metal substrates by gas-static pressing, (iv) explosive implantation of CNT into metal layers, (v) shock-wave compacting of various powder materials with CNT, etc. In addition we study carbon nanoparticle-based emitters produced by electrochemical codeposition of metals with nanodiamond powders or chemical vapor deposited carbon 'needle-shaped' nanostructures using a dc arc plasma activation of triple (methane-argon-nitrogen) gas mixtures.

The film microstructure was studied using AFM, SEM, Raman spectroscopy, X-ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, and EELS to find correlations between the field emission and other film properties. The field electron emission was studied using both a macroscopic phosphor screen setup and a microprobe setup with tungsten probes of 10 μm in radius. Emission I-V dependences as well as emission sites distribution were measured and then analyzed depending on preparation conditions.

It was found that the CNT films produced at certain conditions emit better than other CNT films, and show better emission threshold field (1 V/μm and even lower), higher density of emission sites, and higher working limit of the emission current. Whereas in some cases of the CNT film preparation the emission is not good enough. A comparison is made with chemical vapor deposited carbon 'needle-shaped' nanostructures, which also show good emission properties. Possible field emission mechanisms are considered.

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